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INVESTIGATING THE CHALLENGES OF CROWDSOURCING FOR ENGINEERING DESIGN: AN INTERVIEW STUDY WITH ORGANIZATIONS OF DIFFERENT SIZES

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ABSTRACT

Crowdsourcing has been identified as a valuable paradigm in the open design movement. In engineering design, it offers various benefits, such as the generation of diverse ideas and the involvement of consumers. Despite the potential benefits, there are many ways in which crowdsourcing initiatives may fail. An example of such a failure is when a previously successful initiative for a large organization fails to attract a suitable number of participants with diverse expertise for a start-up. Consequently, the start-up does not receive good sets of ideas, both in quantity and variety. Such failures of crowdsourcing initiatives are common due to the lack of appropriate design of crowdsourcing initiatives based on the organizational characteristics such as its size. While frameworks and guidelines exist for the design of crowdsourcing initiatives, whether these are useful for all sizes of organizations, is yet to be determined. Large organizations such as Procter & Gamble and NASA, now conduct crowdsourcing initiatives regularly. Furthermore, start-ups are emerging that leverage crowdsourcing as an integral part of their business model. On the contrary, small and medium enterprises (SMEs) have fallen behind in the adoption of crowdsourcing processes. In this paper, we aim to identify the challenges associated with crowdsourcing and how and whether these differ according to organizational size. We present the results of an interview study with industry professionals from five organizations of varying sizes, and yield key challenges associated with the application of crowdsourcing. This paper discusses suggested support mechanisms for crowdsourcing in SMEs and directions for further research for crowdsourcing in engineering design.

Keywords: crowdsourcing, engineering design, interviews, research opportunities

1 Introduction

Crowdsourcing is the practice of outsourcing tasks, traditionally performed by employees, to a large group of people [1], typically referred to as the "crowd." Use of crowdsourcing has significantly increased in recent years [2] with many successful examples accelerating crowdsourcing adoption. An example in an engineering design context is Procter and Gamble's "Connect and Develop" initiative which has resulted in 45% of key initiatives being discovered externally and a 65% increase in R&D productivity [3]. Boeing also used crowdsourcing in the design of the 787 with external suppliers contributing to 35% of the overall design and reducing development time by a year [3]. These studies demonstrate the value of crowdsourcing for engineering design organizations. Crowdsourcing is particularly advantageous for design phases such as requirements elicitation, ideation, and concept evaluation.

Despite the advantages of crowdsourcing, some crowdsourcing initiatives are more effective than others, and failure is common [5]. Frameworks supporting the design of crowdsourcing initiatives have began to emerge to guide the crowdsourcing initiative design process. An example is the initiative design framework presented by Panchal [4], shown in

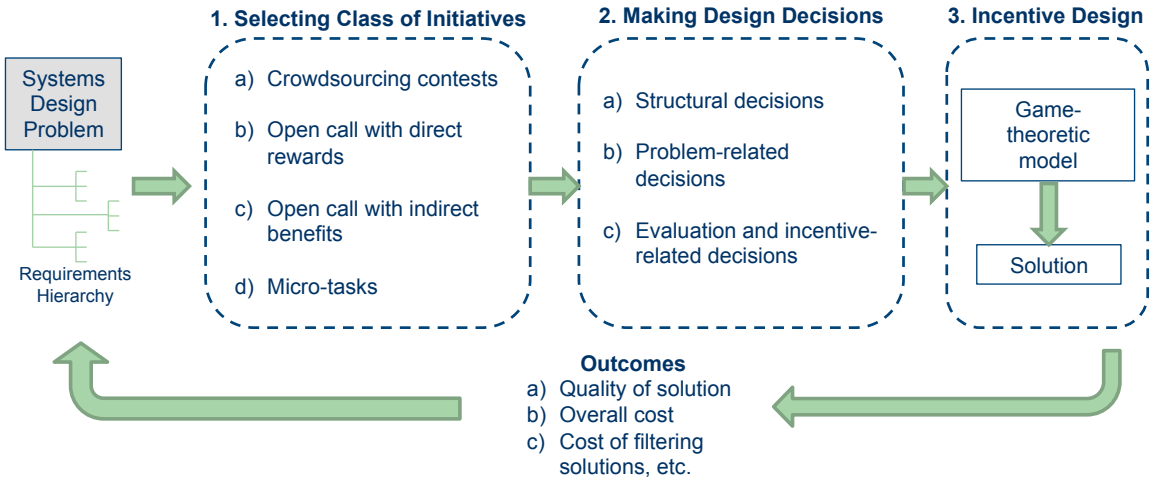

FIGURE 1. A Framework for the Design of Crowdsourcing Initiatives [4]

Figure 1. However, crowdsourcing initiative design frameworks or crowdsourcing initiative design guidelines that account for the difference between organizations of varying sizes is yet to be presented [6].

Organization size is typically defined by its revenue and the number of employees [7]. Other aspects such as company culture, number of locations, and age may also influence how an organization is defined. The taxonomy by Brooksbank [8], as shown in Table 1 is widely used to define organization size [8]. Thus, it is adopted for this paper.

Many studies have proven that significant changes in operations takes place as the company size increases, with management of these changes being fundamental for business survival [9]. In the context of product design, Mital et al. [10] discuss the need to regularly review product development processes with regards to operational effectiveness, as the company grows. This is also discussed by Blauth et al. [11] with regards to the implementation of new initiatives and how the growth of the company can have significant impact on how this is managed.

TABLE 1. Definition of Organizational Size [8]

Organization Type	**Number of Employees**	**Annual Turnover (In $ Million)**
Start-up	< 100	< 10
Small to Medium Enterprise (SME)	$[100, 1000]$	$[10, 1000]$
Large Enterprise	> 1000	> 1000

In existing literature, organization size is considered influential on the success of crowdsourcing initiatives as a consequence of brand awareness and participant reach. Authors including Prpić et al. [12], Palacios et al. [13], and Aten and Thomas [14] discuss the positive impact of "brand exposure" and "cultural capital" in enticing participants. Existing literature also considers crowdsourcing in the context of single types of organizations. For example, Forbes and Schaefer discuss the benefits crowdsourcing offers for large engineering design organizations [5] and published case studies, such as "Connect and Develop" by Huston and Sakkab [3], provide insight into using crowdfunding in one organization. However, existing literature has not focused on how the size of the organization influences the experience of launching and managing a crowdsourcing initiative, and whether existing crowdsourcing frameworks are supportive of all types of organizations.

The authors hypothesize that the challenges associated with applying crowdsourcing vary according to the organization size and that the crowdsourcing initiative design process should also vary to reflect these changes. Thus, the aim of this paper is to identify challenges associated with crowdsourcing from engineering design organizations of varying size, and to determine how and whether the challenges differ. Such an investigation would enable improvement of existing frameworks of crowdsourcing initiative design to ensure that organizations of different sizes can be guided.

The paper is organized as follows. In Section 2, an interview study with five organizations of different sizes is presented. The purpose of the interview was to investigate the challenges face by an organization in conducting crowdsourcing initiatives. In Section 3, the challenges raised by each organization and a discussion on how crowdsourcing challenges vary according to organizational size is presented. In Section 4, we discuss the future work for improvements to existing crowdsourcing initiative design frameworks.

2 Interview Study

We conducted one-on-one semi-structured interviews with five industry professionals from organizations of varying sizes. Each of the professionals has discipline-specific work experience with product design processes. A semi-structured interview style was adopted in order to investigate and compare the challenges raised by interviewees, while maintaining the flexibility to explore responses related specifically to the organization size. No incentives were provided to the interviewees, and interviews were conducted based on their desire to contribute to this research. None of the professionals were aware of the identities of the other interviewees and, to the best of the authors' knowledge, the interviewees do not know each other.

Table 2 lists the discipline-specific experience of the interviewees, and the sizes of their organizations.

TABLE 2. Professional background of interviewees

Interviewee Label	Professional Experience	Crowdsourcing Experience
Professional 1	Work experience with *large* national government organization in the aerospace sector.	Yes
Professional 2	Co-founder of a technology *start-up* based on a crowdsourced data labeling platform.	Yes
Professional 3	Works within an *SME* design consultancy with experience in medical, food and consumer sectors.	No
Professional 4	Works within an *SME* design consultancy with experience in transport, consumer, industrial, and medical sectors.	No
Professional 5	Previously worked in a *large* cooperation in the manufacturing sector as the Head of Open Innovation	Yes

2.1 Data Collection

The interviews were conducted via teleconference calls, which were audio-recorded, with permission of the interviewee, and then transcribed. The interview questions were formulated based on the crowdsourcing experience of the interviewees. The teleconferences lasted for an average of 18 minutes.

We illustrate the structure of the interviews in Table 3. In all the interviews, the first question asked to the interviewee was to describe their discipline, organization and work experience. Then, they were asked about their knowledge and experience or interest in crowdsourcing initiatives. If they did not have experience with crowdsourcing, they were asked what aspects of their work they believed could be crowdsourced.

TABLE 3. Interview structure

Investigation Topic	Motivation	With Crowdsourcing Experience	Without Crowdsourcing Experience
Interviewee's domain and experience.	To understand the context of their responses towards crowdsourcing practices and clarify the type of organization they represent.	*Please describe your professional background and work experience.*	*Please describe your professional background and work experience.*
Crowdsourcing Challenges	To investigate the challenges faced by industry professionals.	*Could you please describe the challenges in implementing the initiatives you described?*	*Why have you not implemented these crowdsourcing initiatives yet?*

2.2 Data Analysis

The transcribed responses of the interviewees were analysed through content analysis [15]. Throughout the analysis, words and sentences were coded to identify the perceived crowdsourcing challenges and a coding scheme was developed to identify these challenges raised by the interviewee. The comments from the experts were coded verbatim to investigate the "challenges" of crowdsourcing. A purely inductive approach was utilized to do so [15]. The coding scheme is agnostic to the length of a particular coded instance. This implies that if the interviewee elaborated on a particular instance such as a "challenge", it was considered as a single coded instance in the transcript.

In order to ensure content analysis reliability, the transcribed interviews were coded several times by the researchers. The inter-rater reliability (IRR) was calculated by taking the ratio of the number of agreements amongst coders for labeling each instance of the "challenges" to the overall sum of agreements and disagreements [16]. A coded instance is considered as an agreement if no clarification was requested amongst the coders towards identifying that instance and it's relationship to the coding scheme. The IRR is given by

$$IRR\% = \frac{\text{Agreements}}{\text{Agreements} + \text{Disagreements}} * 100\% \qquad (1)$$

The disagreements were resolved by the researchers through discussions, and the consensus of the results are presented. However, the IRR scores include the disagreements amongst the coders prior to the discussion aimed towards reaching a consensus. Thus, the IRR score quantifies the reliability of utilizing the coding scheme, as illustrated in Table 4. The results of the content analysis as well as the IRR scores are provided in

Section 3.1.

TABLE 4. Coding Scheme

Criterion	Details	Coded Example
Challenges	This criterion refers to the challenges that the professionals state that they need to overcome in order to successfully to implement a crowdsourcing initiative. Instances of this category are coded verbatim from the transcripts.	*"[trust] is a problem, so ,for example, it's the same problem that Uber faces – how do you trust a completely new driver, who's picking you up" "how to balance when you want to decontextualize but when you also want to make sure you can target well enough so you want to broaden your pool but you don't want to make it so vague that people don't see it as their problem"*

3 Results and Discussion

In this section, the results from the interview study are presented, highlighting the challenges raised by each professional and how this compares to any organizations of a similar size. Then, a discussion associated with the challenges is presented based on the themes that emerged from the challenges.

3.1 Results

In this subsection, the challenges as identified by the professionals are presented along with the IRR scores for the initial round of analysis. Table 5 shows the challenges and Table 6 shows the IRR for each professional. After a discussion regarding the interpretation of the codes, any disagreements were resolved and the consolidated challenges are shown in Table 5.

3.2 Discussion

Several themes associated with the challenges have emerged. In this subsection, each theme is discussed along with the challenges they represent. The companies that raised the challenges, and the context of the challenges, are discussed with a view to determine whether the challenge is unique to certain types of organizations or not. Existing literature is then included in the discussion and conclusions for each theme are drawn that dictate whether or not further support on this challenge is required, and whether the type of support differs between the types of organizations.

3.2.1 Problem definition and formulation A challenge raised and discussed extensively by interviewees was related to the task of defining and formulating a problem for the crowd. In the context of crowdsourcing initiatives, problem definition and formulation refer to how the problem (to be solved) is presented to the crowd [17]. This includes the language used, supplementary documentation and the information shared with the problem.

The challenges with problem framing are raised by Professional 1 and Professional 5 who belong to large organizations and have prior experience with designing crowdsourcing initiatives. Both the professionals discuss the value and intent in enticing participants from different domains and recognize the need to decontextualize the problem. For example, they highlight the need to remove domain specific jargon in order to entice broader pool of participants. This process was recognized as a significant challenge in the crowdsourcing initiative design process with Professional 1 who stated that their 18 month crowdsourcing preparation period was spent predominantly on problem formulation.

We note that Professional 2 (from a start-up) raises the challenge of "identifying crowdsourcable problems". This suggests that the framing of the problem can influence the success of the crowdsourcing campaign, but only larger organizations are able to commit the time to framing the problem while smaller organizations seek to present problems to the crowd that are already deemed as "crowdsourcable". Another reason why problem framing may not be recognized as a challenge by smaller organizations is due to their inability to entice stronger participation as compared to large organizations. Large organizations with brand awareness and marketing budget, may not have difficulty enticing participation. Their focus is instead on enticing the "right" kind of participants. To do so, problem formulation becomes a much more important activity. This is supported by the challenge raised by Professional 1 of "incentivizing participation for different domains". There is an emphasis by larger organizations on compartmentalizing and engaging segments of the potential audience due to an expectation of high participation.

In the context of engineering design, extensive work has been done on understanding problem framing as an integral activity of design thinking [18–21] and, in the context of engineering design contests, Shergadwala et al. [22] discuss the impact of information sharing on participation in design contests. Furthermore, Jiang et al. [23] investigate how characteristics of a problem such as tone of voice and length may impact crowdsourcing success. Yet to be presented, however, is a holistic framework for practitioners to frame problems for engineering design crowdsourcing contests. Furthermore, there are characteristics of a problem such as inclusion of sector jargon, extent of decontextualization and problem complexity that are likely to influence crowdsourcing success. Future research should aim to provide further guidance on problem framing for crowdsourcing for all organizations by accounting for their size and the extent to which they can expend resources for such framing.

3.2.2 Crowdsourcability The crowdsourcability of a problem is representative of the ease with which a problem can be outsourced to the crowd [24]. How crowdsourcable a problem

TABLE 5. Summary of challenges for each professional

Category	Challenges	Professional No.
Problem Definition and Formulation	Formulating a problem to appeal to different domains	1
	Lack of existing guidance on problem formulation for crowdsourcing	1
	Managing information sharing	1
	Formulating the problem	5
Crowdsourcability	Making problems crowdsourcable	1
	Identifying a crowdsourcable problem	2
Resource required	The time and resource required	1
	The time required to manage a crowdsourcing process	4
	The resources required to manage the crowdsourcing process	4
	The time and resource required	5
	The time required to process received responses	5
Managing Stakeholders	Ensuring client is trusting of solution quality	2
	Receiving client "buy-in"	4
	Receiving permission from senior leadership	5
Incentivizing and Motivating Participation	Incentivizing participation for each domain	1
	Motivating participation	1
	Incentivizing participation	2
	Increasing solver retention	2
	Incentivizing participation	3
Defining and Engaging the Right Crowd	Incentivizing participation for each domain	1
	Defining the type of solver required	1
	Finding the right crowd	2
	Finding the right crowd	5
	Creating barriers to entry	5
	Letting go of preconceptions of the right crowd	5
Lack of expertise or case studies	Lack of available expertise	1
	The lack of available case studies	2
	The lack of available case studies	3
	The lack of internal knowledge on crowdsourcing	3
	The lack of available expertise	5
Intellectual Property	Protecting Intellectual Property	3
	Protecting Intellectual Property	4

is can be defined by several characteristics of a problem such as its complexity, the size of the solution space and the required format of solutions [25]. For example, a problem that requires specific domain knowledge to find a solution is less "openable" than a problem that does not require specific knowledge, since the barrier to entry is lower.

The challenges associated with this theme were 1) making a problem crowdsourcable as discussed by Professional 1 and Professional 2) identifying a crowdsourcable problem as discussed by Professional 2. The difference between these challenges raises a discussion on the concept of crowdsourcability and whether it is inherent to the problem or can be achieved regardless of the problem.

Professional 2 defines "identification" of a crowdsourcable problem as a challenge while Professional 1 defines achievement of crowdsourcability as a challenge. This represents two

TABLE 6. IRR for each Professional

Professional	Agree	Disagree	IRR (%)
Professional 1	9	2	78
Professional 2	6	0	100
Professional 3	4	1	75
Professional 4	4	0	100
Professional 5	7	1	86

different mindsets and ultimately two different obstacles in the crowdsourcing initiative design process. While Professional 2 cites the search as the challenge, Professional 1 is referring more to the problem formulation process. The difference between these attitudes and the organization size they are represented by supports the discussion presented in Section 3.2.1. Such an observation raises a new research question:

How does the organizational size influence their approach to addressing crowdsourcability of an engineering design problem?

We hypothesize that smaller organizations would prefer to *identify* crowdsourcable problems as opposed to *formulate* a crowdsourcable problem, whereas, larger organizations would have a flipped preference to address crowdsourcability of problems.

Existing literature does support the notion that problems have inherent characteristics that allow them to be crowdsourced or not, despite manipulation by problem formulation. Thuan et al. [26] discuss factors that influence the decision to crowdsource, Knop and Blohm [25] discuss the task characteristics of crowdsourcing and Buecheler et al. [27] conducted a state of the art review on the crowdsourcability of tasks. Knop and Blohm [25] provide a comprehensive list of the factors influencing the decision to crowdsource with a sector on "problem characteristics" such as complexity. Existing literature therefore suggests a decision process prior to crowdsourcing should be conducted that should include an analysis of the problem's "crowdsourcability".

Current crowdsourcing initiative design frameworks such as the one showed in Figure 1, assume that the "decision to crowdsource" has already been made. Research such as that presented by Knop and Blohm could therefore be combined and presented with Panchal's framework [4] to provide a more holistic supporting framework for organizations. In addition, further research on identifying "crowdsourcable problems" by supplementing Knop and Blohm's work would support smaller organizations by reducing the time needed for problem formulation.

3.2.3 Resource required Running a crowdsourcing initiative requires resource in the form of both employee time and money [5]. Money could be spent indirectly through the use of paid employee time or directly by offering a monetary prize for valuable submissions, paying crowdsourcing platform fees or through hiring external support [4]. Time may be spent on activities such as problem formulation, communicating with potential solvers, spreading awareness of the initiative and evaluating submissions [28].

The SME participants suggest that the resource required as part of the crowdsourcing initiative design process was a barrier to running crowdsourcing initiatives. As shown in Table 5, resource-related challenges were raised by SME participant Professional 1, and Professional 4 and Professional 5 from large organizations. Professional 4 spoke only about the resource required for the crowdsourcing initiative design process while Professional 1 and Professional 5 discussed pre-crowdsourcing resource requirements and post-crowdsourcing resource requirements, such as the evaluation of submissions. Professional 4 talked extensively of the challenge of committing resource to crowdsourcing campaigns, and spoke of the resource required as representing a barrier to their organization. This suggests that while every initiative requires resource, the amount of resource represents a challenge for larger organizations but a barrier for smaller organizations.

Existing literature presents several tools to reduce the time associated with crowdsourcing initiatives but they focus on post-crowdsourcing activities as opposed to pre-crowdsourcing activities. For example, Dissanayake et al. [29] present findings that demonstrate that grouping solvers into teams according to their social and intellectual capital can increase the quality of solutions whereby requiring initiatives of shorter duration. Jiang et al. [30] propose a crowdsourcing contest user interface that allows other solvers to provide feedback, whereby crowdsourcing the evaluation process, as well as the submission process. Further work on automating evaluation of submissions has been presented by Walter and Back, De Alfaro and Shavlovsky, and Wu et al. [31–33]. While existing literature on reducing time and resource exists, it is generally focused on post-crowdsourcing activities such as evaluation. For Professional 4, "pre-crowdsourcing" commitment represented a barrier to entry. It is therefore the case that in order to involve SMEs and smaller organizations, support for practitioners that reduces "pre-crowdsourcing" commitment is required. Initiative design frameworks such as Figure 1 represent this kind of support but effort to frame this knowledge for practitioners may be required.

3.2.4 Managing stakeholders Designing and launching a crowdsourcing initiative as an organization often requires support and permission from relevant stakeholders. For example, in the case of Professional 3 and Professional 4, who both represent design consultancies, they require permission from their client in order to share information and outsource parts of the design process to the crowd.

Resources such as a collation of relevant case studies may

support organizations in managing stakeholders but for some organizations, lack of stakeholder permission may prevent the use of crowdsourcing. As shown in Table 5, these challenges were raised by organizations of different sizes and, as a consequence, the context associated with these challenges are very different. Professional 5 stated the challenge associated with requesting budget from the senior leadership prior to planning and launch of the initiative. Professional 4 discussed their role within a design consultancy and the significant focus on meeting client needs. Furthermore, the key value presented by Professional 4's organizations and other design consultancies, is the specialist and superior ability to create a solution for the client. Suggesting a crowdfunding initiative to a client is counter to the perception that their in-house capabilities are vital for reaching a high-quality solution.

Techniques for overcoming these challenges are likely to be unique to the stakeholders in question. Collation of successful case studies may allow senior leadership teams to be convinced of the value of crowdsourcing but in the case of client-consultant relations, generic tools are unlikely to be supportive. Future work could therefore include the collation of existing case studies, a suggestion discussed further in Section 3.2.7, but academia is unlikely to be able to provide resources to navigate client-consultant relationships in this context. It is therefore worth recognizing that SMEs with business models that rely on fulfilling client demands, may currently be excluded from hosting crowdsourcing initiatives as a consequence of this challenge.

3.2.5 Incentivizing and Motivating Participation

Incentivization in this context refers to both intrinsic and extrinsic motivation to participate in the crowdsourcing initiative. Often, initiatives offer a cash prize but some initiatives involve non-monetary rewards, and often initiatives rely on intrinsic motivations of the solvers to encourage participation. The number of participants and the type of participants are both fundamental to crowdsourcing success and are often cited as factors for crowdfunding failure [34].

All three of the interviewees that raised challenges with these themes stated "incentivizing participation to be a challenge" with Professional 1 and Professional 2 defining further specific challenges associated with their experiences. Professional 2 raised the difficulty of keeping solvers actively engaged in crowdsourcing and Professional 1 raised the challenge of appealing to different domains and motivating participation with a varied incentivization structure. Professional 3, distinct from Professional 1 and Professional 2, specifically discussed the challenge in finding any way to incentivize as opposed to finding the right way to incentivize. As an SME, they discussed the difficulty in offering a large monetary prize and therefore enticing adequate participation.

For SMEs a large monetary prize is often not possible and existing literature currently does not support the exclusive use of non-monetary incentives. For larger organizations offering a significant monetary prize is a lot more achievable based on their higher income and, in most cases, higher R&D budget. Existing literature, however, demonstrates that intrinsic motivations can be very effective in motivating participation. Katmada et al. [35] discuss leveraging intrinsic motivations using gamification, Mao et al. [36] suggest association with a large brand often provides adequate motivation and Füller et al. [37] show that participants are often motivated by "good will", especially when supporting a social cause. Intrinsic motivations associated with brand awareness are difficult for smaller organizations to leverage but other intrinsic motivations could offer a solution for incentivization for small organizations. Existing crowdsourcing initiative design framework include incentivization as a key step in the initiative design process. In the case where a larger monetary prize is not possible, further guidance on creating and leveraging intrinsic motivations should be provided by future research. This support could be fundamental in allowing more smaller organizations to host crowdsourcing initiatives.

3.2.6 Defining and Engaging the Right Crowd

This theme refers to engaging participation from the *right* participant. Crowdsourcing is explored by organizations as a means to gain external insight [1] but receiving many submissions of poor quality from the "wrong" crowd can result in initiative failure [4]. This theme represents the challenges associated with identifying the "right" crowd". Professional 5 found that when appealing to what they thought would be the best solvers they did not get the best solutions. They stated "it wasn't necessarily an uninformed audience; it was actually an audience perhaps too close and involved in the industry to truly innovate". After identifying the "right crowd", the next challenge was engaging it.

Professional 1 and Professional 5 found a challenge in finding the right skills set while Professional 2 found a challenge in identifying the right geopolitical climate for crowdsourcing success. Professional 1 emphasizes the need to appeal to different domains while Professional 5 stated the need to let go of preconceptions in order to find the right crowd. Professional 2 discussed the type of solver with regards to nationality and occupation. For example, they stated that in India there are not as many opportunities to build a secondary income stream so it was easier to motivate participation in India compared to the United States where this opportunity is available. The context of this challenge also differs between Professional 2 and Professional 1 and Professional 5 because Professional 2 is seeking solvers for micro-tasks which require no specific skills. Professional 1 and 5 therefore found a challenge in finding the right skills set while Professional 2 found a challenge in identifying the right geopolitical climate for crowdsourcing success.

This challenge was raised exclusively by organizations who

had hosted a crowdsourcing initiative. This supports the notion that attracting the wrong crowd is often only recognized after submissions have been received. It was therefore, perhaps understandably, not raised by the SME interviewees but it likely to be important in the crowdsourcing process, regardless of organization size.

The difference between the context of these challenges, however, does represent a difference between the organizations and why they focus on this activity. While Professional 2 focused on finding the right crowd to increase participation in general, Professional 1 and Professional 5 focused on finding the right to increase the right kind of participant. We infer that there is an emphasis by larger organizations to assume high participation and to try to segment the crowd.

There needs to be further visibility on how "crowdsourcing inputs" such as the problem description, the information shared and the incentives [38] impacts the amount of participation and the type of participation, and how this then impacts solution quality for a particular problem. Existing literature does provide some insight on how crowdsourcing inputs impact the amount of participation. For example, Zheng et al. suggest that if crowdsourcing contest tasks are "highly autonomous, explicitly specified, and less complex, as well as require a variety of skills", the crowd will be motivated to participate [39]. They also state that that in order to receive "optimal solutions from crowdsourcing contest participants, firms need to improve task design and motivate contest solvers' participation" [39]. Existing literature is lacking, however, on how inputs impact the type of participant and then the solution quality.

To provide holistic support for organizations of all sizes, further work on how characteristics of crowdsourcing inputs impact participation and type of participation should be explored. Smaller organizations require support to increase participation in general while larger organizations, with the luxury of larger participation, need to consider how to focus resources on the type of participants that offer the best submissions.

3.2.7 Lack of expertise or case studies All professionals except Professional 4 identified a lack of expertise and/or a lack of case studies as a challenge associated with running a crowdsourcing initiative. Professional 2 and Professional 3 raise the challenge of running an initiative without existing examples to inspire and replicate while Professional 1 and Professional 5 emphasize the lack of expertise as a challenge. Professional 3 also states a lack of expertise but refers specifically to the lack of in-house knowledge while Professional 1 and Professional 5 raised the lack of external expertise as a challenge.

The context of these challenges suggest that larger organizations prefer to hire external expertise to support crowdsourcing initiatives, while smaller organizations rely on internal organization and therefore value support of case studies. Professional 1 and Professional 5 suggested that expertise was most needed in the process of problem framing for crowdsourcing. Understanding how problem framing can be taught to budding designers and professionals alike is still a topic of research within engineering education and design sciences [19, 40]. Cross discusses how the majority of the problems are ill defined [41] and through pedagogical methods such as project-based learning, the engineers of tomorrow can develop skills such as problem framing abilities [42]. As discussed earlier, however, visibility on the impact of problem description on solution quality is important for understanding. Perhaps with further work in this area, external expertise will become less vital, with organizations able to leverage existing tools to host crowdsourcing initiatives.

With regards to the needs of case studies to support smaller organizations, existing literature recognizes the need for further and consolidation of case studies. Forbes and Schaefer state that "availability [of case studies] for the implementation of crowdsourcing in product development, is limited" [5]. They suggest that case study literature is siloed with authors presenting knowledge based on only specific examples without decontextualizing advice for supporting other crowdsourcing initiatives. For example, Koch et al. present a case study on crowdsourcing for design of government initiatives [43], Brabham et al. present a case study for crowdsourcing transit planning design [44] and Dubey and Rameshwar present a crowdsourcing case study for disaster relief [45]. Consolidation of case studies, with tools that allow selection for replication, could make crowdsourcing more accessible for smaller organizations.

3.3 Intellectual Property

"Protecting Intellectual Property" was raised as a challenge by Professional 3 and Professional 4. Professional 3 and Professional 4 are both from SMEs that have not ran a crowdsourcing initiative and deemed the management of IP as a significant barrier to entry. Existing crowdsourcing platforms such as GrabCAD [46] and Innocentive [47] demonstrate the three ways organizations manage any IP created as part of the context. The three scenarios are as follows:

1. On submission the solver passes all rights to IP to the organization. The solver is included as the inventor for any patent applications, by the rights to the patent belong to the organization.
2. The organization owns the IP but agrees a proportion of royalties to be given to the solver.
3. The solver still has the rights to the IP but the organization has an exclusive license to use the IP.

These three approaches to IP have been standardized on online crowdsourcing platforms [46], so existing infrastructure allows for varying approaches to IP. Furthermore, while

GrabCAD encourages all submissions to be in the public domain, to promote collaboration, Innocentive allows submissions to be accessible only by the organization. Systems are therefore in place to manage both the allocation and access of IP through crowdsourcing campaigns. The authors assume that the challenge for Professional 3 and Professional 4 refer specifically to their sector. In the case of a design consultancy, IP emerging from client projects are usually assigned to the client as opposed to the consultancy. A consultancy-led crowdsourcing initiative may therefore provide confusion to this overall process and therefore presents a challenge to Professional 3 and Professional 4.

Intellectual Property is a core issue in the discussion of the value and viability of crowdsourcing. As a consequence, existing literature on this area is relatively extensive. For example, De Beer et al. [48] "identify and illustrate [...] four approaches for managing intellectual property", Feller et al. [49] propose an integrated user interface to manage IP and Chanal and Caron-Fasan [50] present "crowdsourcing business models" that recognize the implications of IP.

It is understandable that the management of Intellectual Property would be of pressing importance to smaller organizations that may generate the majority of their income from innovative ideas. It is the case, however, that current IP management systems are available either in literature or on platforms, to support this issue. It is likely to be the case that for organizations that rely on the internal generation of IP, crowdsourcing may be inappropriate. In a similar way to overcoming challenges with case studies, consolidation and visibility of IP management systems may support smaller organizations in determining whether crowdsourcing is a possibility.

4 Conclusions and Future Work

In this study, we interview industry professionals from five organizations of varying sizes, and identify their challenges associated with adopting crowdsourcing practices. From the identified challenges, we discuss several emerging themes of crowdsourcing challenges and their relationship with the organizational size. We infer that both large organizations as well as start ups have greater chances of adopting crowdsourcing practices as compared to SMEs. The motivating reasons for start-ups and large organizations to adopt crowdsourcing practices are different. For example, large organizations can commit to spending resources, such as time and money, in all the stages of a crowdsourcing contest such as designing the initiative, executing the initiative, and evaluating the quality of solutions from the crowd. Similarly, startups can adopt novel practices such as crowdsourcing as a part of the organizational culture which in itself is in its infancy. However, for SMEs both commitment of resources as well as changing an established organizational culture is challenging. For SMEs, the lack of monetary incentives implies that they may not be able to motivate the crowd. Such lack of arousal of motivation is compounded by the lack of appropriate problem formulation to attract the right participants. Moreover, SMEs are more concerned about IP issues as compared to large organizations. It is likely to be the case that for organizations that rely on the internal generation of IP, crowdsourcing may be inappropriate. However, further studies are required to understand how SMEs can navigate the issue of IP protection while leveraging the benefits of crowdsourcing towards boosting organizational innovation.

A limitation of this study is the sample size of interviewees. Currently, we have interviewed 5 professionals and further interviews from professionals of varying organizational sizes are required. Additional data would enable us to validate the inferences about the relationship between organizational size and various challenges identified in this study. Moreover, the semi-structured nature of future interviews can include explicit questions regarding the inferences presented in this study about the organizational size and associated crowdsourcing challenges. With respect to further research on crowdsourcing practices, this study supports the need to provide customized decision-support to designing crowdsourcing initiatives based on organizational size.

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